Local conditions.—The pressure at St. Louis, at 8 a. m. August 19, was 29.89 inches; there was a constant decline thereafter until about 9 p. m., when the lowest point was reached, 29.66 inches reduced pressure or 29.06 station pressure; the relative humidity was high during the greater portion of the day, 94 per cent at 8 a. m., 91 per cent at 1 p. m., dropping slowly to 79 per cent by 8 p. m. A thunderstorm appeared in the northwest portion of the city during the early afternoon, the first thunder being heard at 2:55 p. m. This storm moved in an easterly direction to the north of the station; it was very local in character, and was confined to the northern portion of St. Louis and Madison. The storm gradually became more threatening over north St. Louis, the cloud movement indicating a rather violent local disturbance in that locality, but at no time did the storm appear especially destructive at any great distance from its path of action. As its course was 2 miles north of the local Weather Bureau office, it was beyond the vision of the observer. At 3:55 p. m. the storm assumed the characteristics of a tornado, violent winds being first noticeable at about No. 3200 north of Market street and No. 2500 west of the river; it moved almost due east, the extreme width of the path being about seven blocks, from No. 3200 to No. 3900 north. It appears to have bounded at intervals, from the fact that its destruction was less marked at some points along its path than at others. The storm evidently reached its maximum strength from Broadway, No. 500 west, to Second street, where telephone and electric light poles were broken and thrown to the ground, and the Broadway street car service was suspended until the next day; the Granite Iron Rolling Mills, No. 3400 north, seemed to have suffered the most severely, the estimated damage being $25,000; about four other business houses were damaged and twenty-five or thirty dwellings injured. The writer personally inspected the damaged district and noted that the damage usually consisted of unroofed buildings, broken poles, electric and telephone wires; at no point did the damage appear to be irreparable or absolute.

The storm, after leaving St. Louis at the river front, passed eastward to Madison and East Madison, where it continued its devastation. The total property loss in St. Louis, according to conservative estimates, does not exceed $100,000, and perhaps about the same amount in Madison and East Madison.

Three fatalities were reported and twenty persons were injured.

A peculiarity of the storm was its extremely local character. While the storm was at its height at 3:55 p. m. in north St. Louis, the central and southern portions of the city experienced only moderate breezes, partly cloudy sky, and but slight changes in temperature. Very little rain occurred, except in the immediate path of the storm. The temperature at 3 p. m. at this station was 83°; 4 p. m., when the storm was at its height, 82°; 5 p. m., 84°; the maximum wind, which occurred at about 4 p. m., was only 24 miles per hour; the barograph trace shows a steady fall in pressure, reaching 29.13 inches when the storm was passing north of the station, with a very slight rise of only 0.03 of an inch shortly after 4 p. m., and falling thereafter to a minimum pressure of 29.06 inches at about 9 p. m. The instruments at the exposition showed even less variation than did the station instruments.

CLOUDBURST NEAR CITRUS, CAL.

By W. E. BONNETT, Assistant Observer, in charge, Independence, Cal.

On August 8 showers were forming over the mountain peaks at 9:30 a. m. (Pacific time), somewhat earlier in the day than seems usual here. They gradually increased in number and extent until about 11:30 a. m., when the entire sky was overcast and threatening. The first thunder was heard at this time. These conditions culminated in very severe thunderstorms in the ranges, both to the east and west of us.

The most excessive precipitation occurred over what is known locally as Mazuka Canyon, cut in the western slope of the Inyo Range. This opens to a gently sloping sage-brush plain, three miles from the station of Citrus. When the flood emerged from the Canyon it spread itself over the fan-shaped deposit there, and flowed with a front of nearly two miles and a depth of several feet toward the station at Citrus. The country over which the water came is wholly uninhabited and the only damage that was done occurred about the station. Here several hundred feet of the railroad track were washed away and for a greater distance it was covered over with débris. One and one-fourth miles of an irrigating ditch, belonging to the East Side Canal Company, was filled up.

THE ANNUAL AND GEOGRAPHICAL DISTRIBUTION OF CYCLONES OF HIGH VELOCITY (OVER 500 MILES IN TWELVE HOURS) IN THE UNITED STATES, 1893-1902.[1]

By STANISLAV HANZLIK, Ph. D. (Prague).

Summary.—The object of the study, the preliminary results of which are herein summarized, was to determine the influence of areas of high pressure (highs), and especially of the so-called St. Lawrence high,[2] upon the velocity and direction of movements of areas of low pressure (lows). In preparation for this investigation, all cyclones of high velocity (over 500 miles in twelve hours) during the years 1893–1902 were considered. No relation between the velocities of cyclones and the barometric gradient could be made out in the case of cyclones in the western portion of the southern circuit.[3]

The reason for this fact was doubtless that of about 130 cyclones in ten years there were about 110 secondary lows, which were deflected to the south, and the laws of the movements of secondary lows, which are under the influence of primary lows, are extremely complex. The 20 primary cyclones remaining showed too little similarity for purposes of comparison. But it distinctly appeared that the relation of the velocity of cyclones to the gradient was such that higher velocities occurred with weaker gradients in front of the cyclones.[4]

The next point taken up was the geographical distribution of the occurrence and of the velocities of rapidly moving cyclones, and, as is shown in the tables and charts which follow, there is a distinct deflecting and splitting effect on the part of the St. Lawrence high in the case of the eastern portion of the southern circuit track of these cyclones. The lows which are deflected to the right of the high move more rapidly than those which are deflected to the left. The splitting in the northeast is most marked in February and March, and there is practically none in January. This is probably due to the nearly equal velocities of lows and highs in January and to the passage of the southern circuit lows to the left of the St. Lawrence high in November and to the right in December.

No definite answer has been obtained to the question set as the object of this study, but some preliminary results have at

[1] Preliminary report on work done during the year 1903–4 in the course Geology 26 (Climatology: advanced course), given under the direction of Prof. R. De C. Ward, in Harvard University.

The instructor's share in this work has been limited to some general suggestions at the beginning of the investigation, occasional conferences during its progress, and a revision of this report for publication.—ROBERT DE C. WARD.

[2] The term "St. Lawrence high" is attributed to any high which, on its path eastward, hangs persistently in the locality of the Gulf of St. Lawrence, checking the progress of lows from the west.

[3] "Northern circuit" is one main path of circulation of cyclones passing directly eastward (from the Northwest British Possessions) over the Great Lakes and the St. Lawrence Valley to Newfoundland.

"Southern circuit" is second main path of circulation of cyclones along the Rocky Mountain slope southeastward to Texas, thence eastward over the Gulf States to the Carolinas, and thence northeastward to the Banks of Newfoundland.

[4] See E. B. Garriott: Types of storms in January. Monthly Weather Review, January, 1895, p. 10.

least been achieved. In the remainder of the investigation the writer will endeavor to throw some light on the following points:

1. What controls the deflection of rapidly-moving lows to the right or to the left of the St. Lawrence high?

2. Is there any relation between the form, gradients, pressure, and other characteristics of lows and the velocity of progression of the lows?

In the investigation of the second of these two questions, it is hoped that the results obtained will be more exact than has thus far been the case. The difficulty, as above pointed out, in the case of the lows in the western portion of the southern circuit has been the large number of secondary lows. The region of the Atlantic and Gulf States offers primary lows in larger number and in better development.

The charts of the tracks of the centers of low areas published in the MONTHLY WEATHER REVIEW for the years 1893–1902, inclusive, were taken as the basis of this work. The only lows considered were those which, when the tracks were measured, showed a velocity of progression of 500 miles or more in twelve hours.[5] The error in measuring the lengths of the tracks lies within the limits of error of the scale on the maps. It is, therefore, possible that some tracks showing velocities of very nearly 500 miles in twelve hours may have been overlooked.

TABLE 1.—*Number of fast storms.*[6]

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1893	32	18	25	16	14	6	5	2	14	7	17	20	176
1894	21	23	29	2	3	6	5	8	13	5	23	18	156
1895	19	14	15	20	7	1	9	9	13	12	12	18	149
1896	11	20	17	9	8	11	8	14	10	5	19	24	156
1897	14	24	14	7	6	8	6	4	11	14	14	22	144
1898	32	12	16	15	9	11	8	4	7	8	17	8	147
1899	30	21	29	11	9	10	4	1	13	11	14	22	175
1900	26	20	29	7	8	3	14	7	14	8	16	27	179
1901	32	23	16	4	6	6	6	6	10	15	18	23	165
1902	17	8	21	11	9	10	9	7	10	9	7	21	139
Average	23.4	18.3	21.1	10.2	7.9	7.2	7.4	6.2	11.5	9.4	15.7	20.3	158.6

During the whole period under review there were, as shown in Table 1, 1586 cases of at least 500-mile progression in twelve hours. The numbers for the first two years are somewhat larger than they should be, because the maps in the MONTHLY WEATHER REVIEW for those years cover a larger area than do the maps published since. Hence, some lows over the Atlantic Ocean and east of Newfoundland are included in the count, whereas in the maps at present employed these areas are omitted The number of rapidly-moving lows varies from year to year about ± 10 per cent from the mean, the greatest differences in percentages being 87.7 per cent in 1902 and 110 per cent in 1900.

If we follow the numbers of rapidly-moving lows from month to month, we see that the greatest number comes in January, with 23.4 as an average, and the smallest in August, with 6.2.

Three characteristic features of the monthly changes are: 1. A minimum between January and March. February has 18.3 against 23.4 in January and 21.1 in March. Even if corrected by addition of one-tenth, February still has only 20.1 (18.3+1.8). 2. The large number of rapidly-moving lows in September (11.5) in comparison with October (9.4). 3. A slight increase in the numbers in July (7.4) as compared with June (7.2) and August (6.2).

If we note the numbers of fast storms in February in each of the ten years, we see that in six years (1893, 1895, 1898, 1899, 1900, 1902) that month had fewer than January and March, in two years (1896, 1897) February had more than January and March, in one year (1894) it had more than January and fewer than March, in one year (1901) it had more than March and fewer than January. In seven out of ten years March had more rapidly-moving cyclones than February.

In seven years the numbers of fast storms was greater in September than in October (1893, 1894, 1895, 1896, 1899, 1900, 1901).

The maxima do not always come in January, nor the minima always in August. In ten years the maximum number of fast storms was distributed by months as follows: January, 4; March, 3; December, 2; February, 1; April, 1. The minima came as follows: August, 5; June and April, 2 each; October and November, 1 each.[7]

In order to eliminate the discrepancies caused by the different numbers of days in the different months, each year was divided into 10-day periods, and curves were then drawn for each year and for the average of the ten years.

Fig. 1 shows the depression in February and the increase above the average in September, with a depression in October. Following the mean curve through the whole year, the conditions may thus be summarized: In the first ten days of April the number of fast storms is equal to the average (4.35 in ten days), it is below the average for April, May, June, July, and August, with some slight fluctuations; in the first half of September it rises above the average, falls again, and again rises above the average in the beginning of November, remaining in that relation till the end of March, with a depression in February. There are, therefore, two maxima of occurrence of rapidly-moving cyclones:

1. The primary winter maximum from the first half of November up to the end of March.

2. The secondary autumn maximum in September.

The rapid fall below the average at the end of March and the beginning of April is characteristic of each year, except 1895 and 1898, when there was a delay of one month.

In the MONTHLY WEATHER REVIEW the average velocities of high and low areas are given for each month. The number of half days occupied by the passage across the United States of all the cyclones in each month of the ten years was expressed by 100, and a computation was made as to what percentages of half days belong to the fast storms, and also as to how these percentages are distributed among the storms of different velocities, e. g., 500–600 miles in twelve hours; 600–700 miles in twelve hours, etc. For example: The time occupied in the progression of all cyclones in January, 1893, was 79 half days, in 1894 it was 84 half days, etc. In the ten years, 1893–1902, the time thus occupied in the progression of cyclones in January was 869 half days. Of this number the fast storms took up 234 half days or (234 : 869) 26.9 per cent. This percentage may to some extent serve as an expression of the "storm activity" of the month. Computations of similar nature may be carried out for the length of the tracks of rapidly-moving cyclones in comparison with the length of all cyclonic tracks.

In general, if the half-day storm track be taken as the basis of measurement we note:

1. That one-quarter of our winter cyclones belongs to the "fast-storm" class, the maximum proportion coming in January, and the percentage decreasing toward summer, being 10 per cent in the summer months, with a minimum (7.7 per cent) in August.

2. The percentage in February is smaller than in January and March; there is a high percentage in July (as compared with June and August) and in September, with a decrease in October.

A comparison of the data in Table 2 with the average

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[5] Following Loomis.

[6] By "fast storm" is meant a cyclone which moves 500 miles or more in twelve hours.

[7] The year 1902 had two equal maxima and two equal minima.

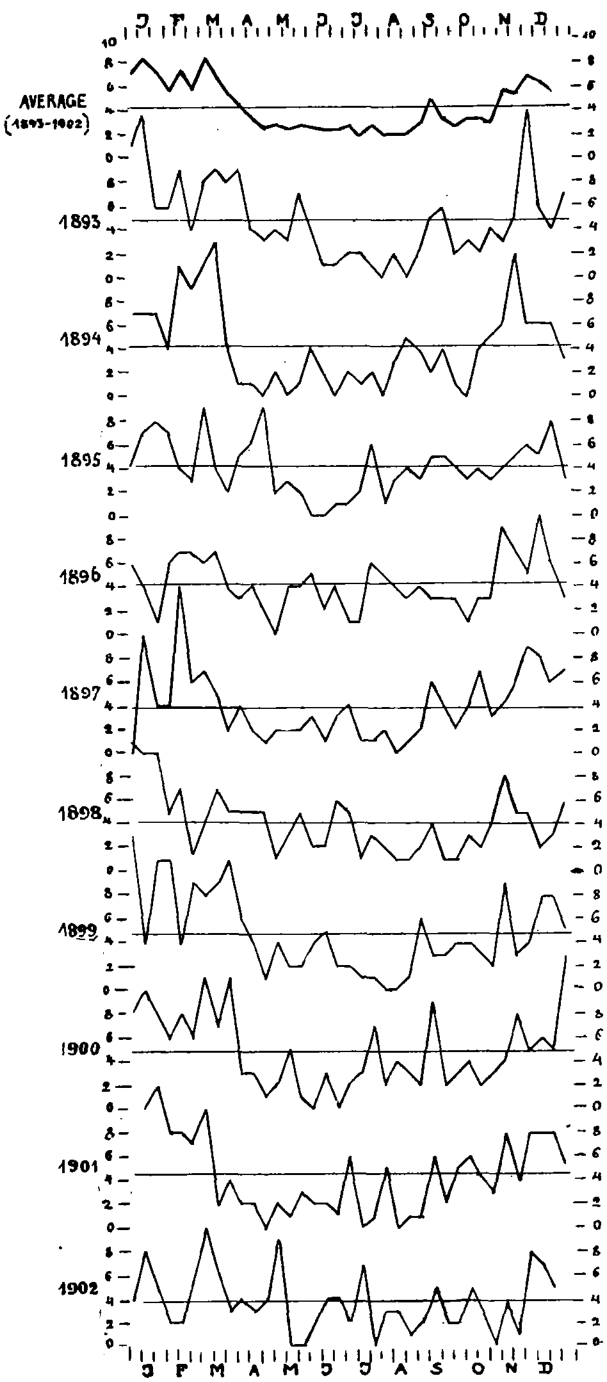

FIG. 1.—Number of rapidly-moving storms in each period from 1893 to 1902, inclusive.

hourly velocities of all storms in each month (last column, Table 2) is interesting, especially in July. As the average hourly velocities do not show the February decrease and the September increase above noted, some explanation of this discrepancy must be sought in the influence of the lows that move less rapidly than 500 miles in twelve hours.

The question arises, How shall these two peculiarities in the yearly distribution of fast storms, viz, the depression in February followed by an increase in March, and the increase in September followed by a decrease in October, be explained? Are these regular features of every year, due to slight but regular more or less marked disturbances in the general circulation, or are they only features of the period under review? The writer offers no answer, but wishes to point out that both of these peculiarities are alike in the following respects: The decrease is followed by an increase in the spring (February, March) and the increase is followed by a decrease in the fall (September, October) and both features occur at the time when the sun is crossing the equator.

TABLE 2.—*Duration of cyclones of different velocities (1893-1902) expressed in percentages of the aggregate duration.*

	Per cent of cyclones. (Velocity less than 500 miles in 12 hours.)	Per cent of cyclones. (Velocity more than 500 miles in 12 hours.)	500-600 miles in 12 hours.	600-700 miles in 12 hours.	700-800 miles in 12 hours.	800-900 miles in 12 hours.	900-1000 miles in 12 hours.	1000-1100 miles in 12 hours.	1100-1200 miles in 12 hours.	1200-1300 miles in 12 hours.	Average hourly velocity of all cyclones.
January	73.1	26.9	11.4	7.6	4.5	2.0	0.9	0.2	0.2	0.2	31.3
February	77.2	**22.8**	9.5	6.6	3.7	1.3	1.3	0.5	0.1	......	30.4
March	75.8	24.2	11.5	6.4	3.7	1.9	0.5	0.3	0.2	......	29.3
April	87.8	12.2	5.6	4.2	1.6	0.6	0.2	......	......	......	25.0
May	88.9	11.1	5.8	2.5	1.7	0.6	0.1	0.3	......	0.1	23.4
June	89.8	10.2	4.8	2.2	1.6	1.0	0.5	......	......	......	22.5
July	88.7	**11.3**	4.9	3.5	1.4	1.2	0.3	......	......	......	**22.9**
August	92.3	7.7	3.5	1.9	1.3	0.6	0.4	0.1	......	......	21.8
September	86.9	**13.1**	6.1	3.2	2.5	0.8	0.3	0.2	......	......	23.6
October	89.2	10.8	5.3	3.8	1.0	0.5	0.2	......	......	......	24.5
November	81.1	18.9	8.9	6.0	2.8	0.7	0.5	......	......	......	28.9
December	76.1	23.9	8.8	6.4	4.5	2.8	0.8	0.4	0.1	0.1	31.6

After discussing the yearly occurrence of rapidly-moving cyclones, the next question taken up was the geographical distribution of such cyclones and their principal tracks. In studying this subject, a map of the United States was divided by means of parallels and meridians, into 5-degree squares, each square being numbered, beginning with 1 in the extreme northwest and ending at 90 and 91 over Cuba. Fig. 2.

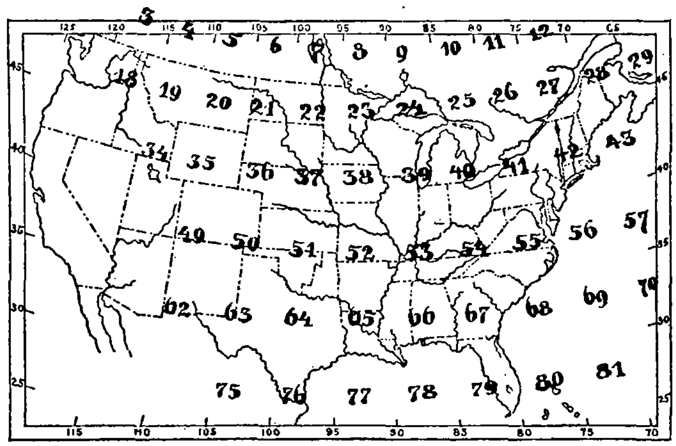

FIG. 2.—Map of the United States, showing system of numbering 5-degree squares.

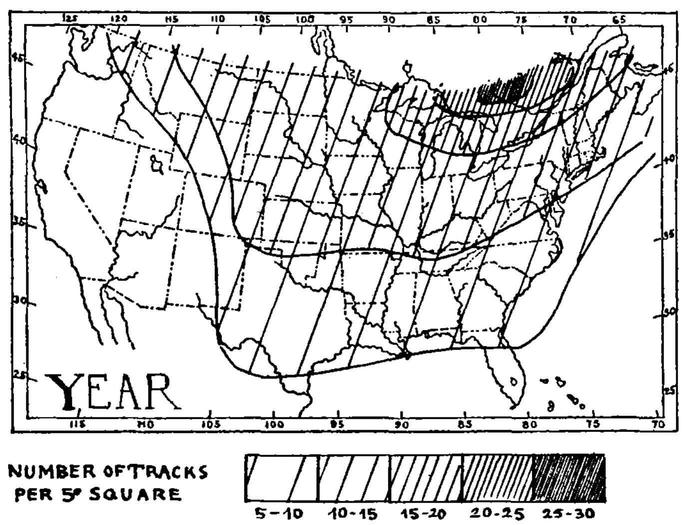

FIG. 3.—Geographical distribution of fast-moving cyclones (period 1893-1902).

In each of these squares was entered the number of all fast storms which passed across that square, and from these data it was possible to see the changes in the numbers of such storms in each square for each month. The fast storms west of the Rocky Mountains were omitted. The geographical distribution of these storms is shown in fig. 3 and in Charts XI and XII and Table 3.

TABLE 3.—*Numbers of fast storms passed each square in ten years.*

Squares.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
SQUARES 2-14, NORTH LATITUDE 50°-55°, WEST LONGITUDE 60°-125°.												
2	2	5	2	1	0	1	1	0	1	2	4	5
3	8	8	2	5	1	4	2	1	2	5	14	10
4	20	13	6	8	4	3	7	3	8	9	15	17
5	17	12	6	7	5	6	8	5	8	10	17	16
6	18	11	5	5	5	6	11	11	8	12	10	22
7	12	9	8	4	2	10	7	6	8	8	6	19
8	7	2	4	1	3	10	0	3	6	4	7	14
9	3	2	2	1	2	6	2	4	8	3	1	9
10	1	0	2	0	1	3	0	3	2	2	1	1
11	0	0	2	0	0	2	0	2	4	2	4	4
12	1	0	4	0	1	1	2	2	4	1	5	5
13	3	1	4	0	2	1	2	2	6	2	4	4
14	1	1	2	0	0	0	0	0	4	0	2	1
SQUARES 18-30, NORTH LATITUDE 45°-50°, WEST LONGITUDE 55°-120°.												
18	8	9	11	8	3	3	4	0	4	6	10	9
19	15	9	15	8	6	1	7	0	9	7	11	9
20	18	17	21	14	10	6	11	5	16	8	15	15
21	18	15	12	14	12	7	12	8	12	7	15	13
22	18	10	10	7	10	6	16	17	11	10	17	19
23	15	7	7	6	10	11	10	16	14	12	13	21
24	22	11	17	11	15	22	13	15	24	11	15	19
25	22	15	25	11	14	25	18	9	24	13	23	24
26	28	19	30	14	16	20	20	11	24	19	30	24
27	34	20	25	17	13	16	14	6	23	18	32	21
28	30	17	25	15	9	5	7	8	20	13	24	24
29	21	16	23	11	1	2	2	3	13	8	12	17
30	13	10	11	5	0	0	0	1	9	5	4	14
SQUARES 34-45, NORTH LATITUDE 40°-45°, WEST LONGITUDE 55°-115°.												
34	5	7	4	4	3	3	2	1	3	1	1	2
35	11	9	16	7	3	4	1	5	8	1	7	9
36	12	15	16	8	10	6	6	8	12	9	17	18
37	18	10	14	5	5	9	10	16	14	6	16	12
38	20	8	11	4	9	6	16	13	10	3	13	14
39	15	15	14	5	7	4	14	5	6	3	16	8
40	28	23	23	4	9	7	8	2	7	4	18	18
41	35	17	19	4	5	4	5	3	3	4	17	22
42	32	18	27	3	3	1	3	1	8	7	10	22
43	31	20	21	4	1	3	2	1	6	5	11	19
44	15	17	11	2	0	1	2	0	3	4	3	13
45	4	4	5	0	0	0	0	0	0	1	1	5
SQUARES 49-58, NORTH LATITUDE 35°-40°, WEST LONGITUDE 60°-110°.												
49	4	7	7	1	3	1	0	1	3	0	3	5
50	11	20	16	16	9	3	2	3	6	2	10	11
51	13	11	22	5	5	3	9	9	4	2	9	11
52	15	10	20	4	7	2	4	3	0	4	10	13
53	17	16	21	10	5	2	1	1	3	3	9	20
54	16	17	21	5	4	1	0	1	3	2	3	19
55	20	14	14	9	6	1	0	1	4	5	4	17
56	18	8	12	3	1	2	0	0	3	5	3	8
57	9	3	4	0	0	1	0	0	1	1	0	1
58	1	0	1	3	0	0	0	0	0	0	0	0
SQUARES 62-70, NORTH LATITUDE 30°-35°, WEST LONGITUDE 65°-110°.												
62	7	5	3	4	3	0	0	0	0	0	2	2
63	10	9	7	5	4	0	0	0	1	0	7	8
64	10	13	9	5	4	1	0	1	0	4	8	14
65	12	18	12	5	4	2	0	1	3	5	5	16
66	14	15	10	5	4	1	0	0	2	1	4	10
67	12	15	15	4	5	0	0	0	3	3	1	6
68	10	9	10	1	4	0	0	0	4	4	1	9
69	4	3	4	0	1	0	0	0	0	0	0	4
70	1	2	2	0	1	0	0	0	1	1	0	4
SQUARES 75-81, NORTH LATITUDE 25°-30°, WEST LONGITUDE 70°-105°.												
75	3	3	1	0	0	0	0	0	0	0	1	1
76	10	10	5	4	0	1	0	0	0	3	2	11
77	3	9	4	2	0	1	0	0	1	1	0	7
78	1	6	3	0	0	0	0	0	0	0	0	3
79	2	2	3	0	0	0	0	0	0	1	0	2
80	9	1	2	0	0	0	0	0	0	0	0	2
81	0	0	1	0	0	0	0	0	0	0	0	1

The data for the 10-year period here considered are not regarded as giving a satisfactory view of the geographical distribution and of the principal tracks of fast storms during the summer half-year, because of the small number of such storms at that season. For the winter half-year, however, the conditions are much more satisfactory, especially as regards the principal tracks, in drawing which the author has made use of maps that he has constructed, showing for each month the tracks of all fast storms during the 10-year period. (These monthly track charts of rapidly-moving cyclones are not here reproduced.) If these small charts are examined it will be seen that they may be classified into two groups:

1. Those with northern circuit track (figs. 4, 5, 6, 7, 8, 9, Chart XI).

2. Those with northern and southern circuit tracks (figs. 10, 11, 12, 13, 14, 15, Chart XII).

In the first group the maps are much alike. The main track, with its maximum number of fast storms in the Lake Superior region, in Ontario, and in Quebec, reaches as far south as latitude 45° north in May, June, and October, and to latitude 40° north in July, August, and September, forming a loop over the upper Mississippi and Missouri region. The change in the track from September to October and from October to November is notable.

In November the southern circuit begins to be established. This reaches to between latitudes 35° and 40° north, and the eastern part of the southern circuit crossing the Lake region keeps rather to the Canadian side, trending in an east-northeast direction. There is a remarkable decrease in the occurrence of rapidly-moving cyclones in the upper Mississippi region, which continues until March, and is even faintly seen in April.

In December the conditions become more exaggerated. The southern circuit reaches as far as latitude 35° north, and while trending east-northeast it is joined by minor tracks from the Gulf and South Atlantic States. The southern-circuit track goes along shore, off New England, while the northern circuit keeps on the Canadian side.

January, with its maximum number of fast storms, is much like November. The western branch of the southern circuit is broad, and is clearly separated from the western part of the northern circuit. These both join in the east, passing over the Northeastern States, which are in this month a region of fairly uniform distribution of fast-storm frequency.

In February the western branch of the southern circuit comes pretty nearly from the north; the eastern branch splits into two tracks to the south of the Lakes, the northern one of these two joining the northern circuit, while the southern joins the Atlantic track coming along the coast from the Southern States.

The main tracks in March are similar to those in February, with the exception that the southern circuit does not reach as far south as in February and splits somewhat sooner. The eastern portion of the northern circuit is very marked in Canada.

With April, the transition month, the eastern part of the southern circuit breaks; there are some breaks in the western and eastern portion of the southern circuit and in the Canadian portion of the northern circuit. In April, the summer half-year circulation, which is confined to the northern circuit, begins again.[8]

All the maps from November to March, inclusive, have two features in common, viz, the relatively infrequent occurrence of fast storms in the district between the Missouri and Great Lakes, and the splitting of the southern circuit into two branches, one of which crosses over to Canada, and the other of which passes off-shore along the New England coast. The explanation of these two features is to be found in the occur-

[8] The author wishes here to call the attention of the reader to what Prof. F. H. Bigelow says regarding storm tracks and their changes from month to month in Weather Bureau Bulletin No. 20, Storms, Storm Tracks, and Weather Forecasting.

rence of the Central States and the St. Lawrence highs, and in the different velocities of lows and highs.

If a storm which, because of its energy, form, or gradients, is adapted for a very rapid progression, comes up against the rear of a high which lies in its path, the velocity of the low is checked somewhat, but the storm at last finds its way around the high to the right or to the left of the center. A measure of the retarding effect of highs seems to be found in the difference of the velocities of lows and highs; if the velocities are equal, there is neither retardation nor deflection.

The retarding or deflecting effect increases with an increasing velocity of the low or a decreasing velocity of the high. It would suffice for the present purpose to give the differences between the velocities of rapidly-moving lows and the highs which retard them for each month over the Great Plains and the Northeastern States; but not having measured the velocities of the high areas in the regions named, the writer has been obliged to content himself with the average velocities of all lows and highs. These data are given below (Table 4) and furnish a satisfactory explanation of the influence of the St. Lawrence high. To this question regarding the St. Lawrence high further discussion will later be directed, but attention may here be called to the fact that the retarding effect of highs on lows is greatest in December and least in January.

TABLE 4.—*Average velocities (in miles per hour) of all highs and lows.*

	November.	December.	January.	February.	March.
Lows	28.9	31.6	31.3	30.4	29.3
Highs	26.0	25.5	29.6	26.0	25.8
Difference, low − high.	+ 2.9	+ 6.1	+ 1.7	+ 4.4	+ 3.5

In the study of the fast storms which follow the western part of the southern circuit, there have been collected from the author's monthly track charts above mentioned all tracks that had an azimuth between south-southwest and southeast. In each of these cases sketch-maps were drawn, showing the general distribution of pressure over the United States as indicated on the Washington weather maps. It was found that the fast storms passing southward along the eastern base of the Rocky Mountains are in general under the influence of high pressure belts, which may be classified as follows:

1. High pressure in the central region.
2. High pressure on the Pacific coast or Rocky Mountain Plateau.
3. High pressure in Alberta.

The effect of conditions 2 and 3 is to accelerate the progression of the low, while a high area in the central region retards the advance of the storm and causes its deflection to the south. This last-mentioned high (1) is the most important of the three, and the maps on which these conditions of pressure prevailed were divided into four pressure-type groups, viz:

(*a*) The eastern high has its maximum pressure in the Lake region, and its isobars form ellipsoidal loops far south to the Gulf States.

(*b*) The eastern high has its maximum pressure in the South-central, Eastern, Gulf, or South Atlantic States.

(*c*) The link type between 1 and 2, where two highs, one in the Lake region and the other in the south, together form a "saddle."

(*d*) Scattering cases, which are too complex to be classed in any of the three preceding groups, but resemble type 2.

After completing the foregoing classification the writer had access to Professor Bigelow's Storms, Storm Tracks, and Weather Forecasting and found that the types *a* and *b* correspond to the high areas accompanying Professor Bigelow's North Pacific type[9] and Alberta type[10] (page 35). The "saddle" type, usually a transition type, frequently changes into type *a* or *b*, so that the high pressure in the south or north disappears. Thus it appears that the fast storms that move south along the eastern Rocky Mountain slope over the Great Plains are controlled in their path by the highs of the North Pacific and Alberta types.

The detailed study of the influence of the St. Lawrence high upon the rapidly-moving storms of the southern circuit is to form the second division of this investigation. At present the following facts can be stated:

In November there is no splitting of the track, because the southern circuit does not reach far south and, therefore, all fast storms pass the St. Lawrence high, leaving it to the right.

In December the majority of the fast storms of the southern circuit pass the St. Lawrence high in such a way that they leave it on their left.

About January, as was stated above, the fast storms pass with a fairly evenly distributed frequency over the Northeastern States, and it may be due to this fact that the lows and highs do not differ much in velocity (see Table 4). In this month some of the fast storms, especially those from the northern circuit, cross the main broad track in New England nearly at right angles, showing very distinctly the deflecting influence of the St. Lawrence high.

In February and March, when the southern circuit shifts northward, the influence of the St. Lawrence high is very marked in deflecting the path of fast storms. "Special attention," as Professor Bigelow points out, "should be directed to the probable behavior of the St. Lawrence high, as upon this will depend success in forecasting the advance of large storms from the southwest."

The following table (5) shows the number of fast storms which passed over the Northeastern States (5-degree squares Nos. 25, 26, 27, 40, 41, 42) and it will be seen that there is a marked falling off in square 41 (New York and Pennsylvania) in the months of February and March, thus distinctly showing the influence of the St. Lawrence high. The 5-degree squares are naturally too large and give too general a view. One-degree squares would bring out the contrasts much more sharpely:

TABLE 5.—*Number of fast storms passing over the Northeastern States.*

	25	26	27	40	41	42
December	2.4	2.4	2.1	1.8	2.2	2.2
January	2.2	2.8	3.4	2.8	3.5	3.2
February	1.5	1.9	2.0	2.3	1.7	1.8
March	2.5	3.0	2.5	2.3	1.9	2.7

The data used in tracing the frequency of fast storms were also used in determining the average hourly velocities of fast storms in each square. The sum of all velocities marked in each square was divided by twelve times the number of fast storms which passed across the square. This was done for the autumn and winter months (November to March), omitting States west of the Rocky Mountains. The averages are given in Table 6.

These numbers do not, of course, give the velocity of storms along the main tracks which are above drawn, but average velocity of storms along all tracks which crossed each square in any direction. The true velocity for each track might be

[9] The North Pacific type.—"These (storms) come in over the extreme northern coast, near Vancouver, and separate about equally in numbers into two paths, of which the first is directly eastward over the Lakes and the second far to the southeastward along the mountain slope, generally reaching northern Texas. In this case a high covers the central valleys and the Missouri Valley, the weight of it being near the northern boundary, whereas in the Alberta type it is heaviest in the Gulf States."

[10] The Alberta type.—"When a low forms in the extreme northwest it is generally found that another low covers the Gulf of St. Lawrence and that an extensive high area occupies the central valleys and the Gulf States * * *. About one-third of the storm centers will be deflected into the southern course and these are much more erratic in their action and harder to forecast."

obtained by taking the cosine of angle between the direction of average main track and the direction of any fast storm in each square. This would obviously be a very laborious piece of work when the number of fast storms and of the squares is recalled.

TABLE 6.—*Average hourly velocity (in miles per hour) of fast storms in each 5-degree square.*

Square No.	November.	December.	January.	February.	March.	Square No.	November.	December.	January.	February.	March.
2	47.9	52.3	49.2	49.2	58.7	40	55.0	62.5	59.6	56.5	55.2
3	49.6	50.5	58.2	53.1	59.6	41	54.9	55.6	56.5	55.7	57.5
4	50.5	48.9	53.2	51.1	65.2	42	51.8	57.2	57.5	52.3	57.5
5	52.6	52.9	52.8	53.1	66.9	43	50.6	59.4	59.2	55.2	56.0
6	54.2	56.1	53.3	53.6	53.3	44	50.5	58.9	61.1	57.2	53.5
7	53.6	57.8	55.6	50.9	47.3	45	43.7	53.2	59.2	54.2	56.1
8	53.0	56.3	57.2	45.0	46.2						
9	50.0	59.1	65.6	45.2	54.6	49	48.6	60.3	58.2	57.0	54.7
10	51.7	60.4	74.5	......	......	50	49.9	58.6	56.0	56.9	52.4
11	54.2	65.0	......	......	55.6	51	53.3	58.1	56.7	52.5	51.8
12	52.5	61.3	41.7	......	55.2	52	51.2	61.3	54.5	51.9	52.7
13	47.5	57.5	58.7	49.6	58.3	53	52.1	57.2	52.3	57.5	55.2
14	44.2	54.2	45.0	62.9	50.2	54	56.5	56.9	57.0	61.9	57.8
						55	54.0	51.6	58.4	54.1	61.8
18	57.5	61.5	53.2	60.3	54.8	56	55.4	55.2	57.7	59.5	58.9
19	60.0	59.6	57.4	57.7	54.3	57	......	63.3	62.2	65.5	48.5
20	57.8	62.5	61.0	58.1	61.6	58	......	......	63.7	......	50.4
21	55.6	58.7	57.8	62.4	60.1						
22	54.6	55.8	54.1	59.6	55.2	62	51.4	57.7	53.7	61.7	61.1
23	55.7	56.5	53.0	53.6	51.6	63	51.3	55.5	52.9	61.9	58.0
24	53.9	58.6	56.3	57.5	51.8	64	49.2	57.6	52.3	59.1	57.2
25	52.7	59.5	57.8	52.7	53.9	65	51.3	61.2	59.5	57.7	58.2
26	54.2	57.9	54.5	55.5	52.4	66	53.6	62.3	65.2	60.9	55.0
27	53.6	53.4	56.4	54.8	52.5	67	46.7	50.5	64.8	64.8	55.5
28	53.2	54.2	56.2	51.3	52.2	68	47.9	53.8	61.5	56.6	53.2
29	51.0	54.6	52.1	53.2	52.7	69	......	57.5	50.2	59.2	50.8
30	52.5	54.8	55.3	54.0	51.2	70	......	70.6	55.0	58.8	64.2
34	63.7	73.3	59.8	59.2	57.4	75	55.4	51.2	51.6	63.5	68.3
35	56.3	64.9	60.4	60.7	56.7	76	50.2	58.4	57.4	53.9	55.0
36	56.2	58.2	62.5	59.5	57.6	77	......	60.1	60.8	54.1	52.6
37	55.3	58.0	58.9	59.1	51.2	78	......	62.4	59.1	56.8	53.9
38	54.5	59.1	52.8	61.9	52.7	79	......	75.9	59.0	56.6	44.2
39	53.1	63.6	55.7	57.6	57.4	80	......	83.1	......	49.2	69.5
						81	......	78.7	......	......	84.2

The common features of these sketch-maps, on which have been drawn the lines of 50, 55, and 60 miles per hour, are as follows (see Chart XIII):

1. The high velocities (over 60 miles an hour) in the West along the Rocky Mountains.

2. The high velocities (over 60 miles an hour) along the Atlantic coast and also offshore.

In the second case, the high velocities in the east of storms of the southern circuit progressing northeast come in November in the Lake region when the storms cross over to the Canadian side. December is similar to November, except that in the case of the southern circuit a branch track from the Gulf States, with high velocities, joins it, and on the average all velocities are increased 5 miles an hour as compared with November. In January the highest velocities are in the Gulf States and offshore, over the Atlantic, these being due to storms from the western Gulf and South Atlantic States, which enter the branch of the southern circuit trending northeast.

The February map looks somewhat confused, but there seems to be a tendency to return to the distribution of velocities noted in December. The velocities in the Southeastern States are high, but they are lower where the track divides. In March the velocities in the West decrease, the highest velocities are over the Atlantic, where the right-hand branch of the divided southern circuit meets the storms coming from the Gulf and South Atlantic.

It is noticeable that in the months of December to March, in which the eastern portion of the southern circuit divides, the average velocity of fast storms along the right-hand, off, or alongshore track, is greater than that of the left-hand, continental track. An obvious explanation is that the storms offshore move with much less friction over the ocean surface.

In Table 7 are compared the average velocities of the left-hand, or Canadian branch (represented in squares 26, 27, 28) and those of the right-hand or alongshore branch (represented in squares 41, 42, 43) with the differences between these velocities. In all but two cases the differences are positive, which confirms the greater velocity of the alongshore track. The differences would be more striking if smaller squares had been taken. A similar attempt was made in the case of the summer half-year, but was unsuccessful. Data for twenty to thirty years would be necessary in order to give an idea of the distribution of the average velocities in summer.

TABLE 7.—*Comparison of average velocities (in miles per hour) of storms along the two branches of the southern circuit.*

[Squares 26, 27, 28, represent the left-hand or Canadian branch; squares 41, 42, 43, the right-hand or alongshore branch.]

Squares No.	December.	January.	February.	March.
41	55.6	56.5	55.7	57.5
26	57.9	54.5	55.5	52.4
Difference (41 − 26)	− 2.3	+ 2.0	+ 0.2	+ 5.1
42	57.2	57.5	52.3	57.5
27	53.4	56.4	54.8	52.5
Difference (42 − 27)	+ 3.8	+ 1.1	− 2.5	+ 5.0
43	59.4	59.2	55.2	56.0
28	54.2	56.2	51.3	52.2
Difference (43 − 28)	+ 5.2	+ 3.0	+ 3.9	+ 3.8

THE UNUSUAL RAINFALL OF FEBRUARY AT HONOLULU.

By R. C. LYDECKER, Territorial Meteorologist. Dated March 17, 1904.

The rainfall for February was from four to five times the normal, which is given as 5.6 inches. The average rainfall reported last month was 24.87 inches. According to the monthly summary, Oahu suffered the most in the storms; Maunawili, on this island, reported a fall of 44.65 inches, while in twenty-four hours at the same place 12.50 inches of rain fell. Hawaii suffered the least of any of the islands in the storm, though the big island is usually well to the front in the rain records.

I inclose a barograph sheet (fig. 1) showing the fluctuation of the barometer at Honolulu during the week of heaviest rainfall. The previous records of lower pressure than is shown on this sheet (29.59 on the 11th) are as follows: January 28, 1881, 29.40; February 5, 1901, 29.49; February 13, 1891, 29.57; November 15, 1900, 29.58; February 11, 1904, 29.59.

On this island the rainfall record of 44.25 inches at Luakaha, March, 1902, was broken by a fall of 44.65 at Maunawili. There was no warning of the storm's approach, which set in on the afternoon of the 6th, and between 3 p. m. of that date and 9 a. m. of the 7th 6.22 inches fell at the Weather Bureau. On the 15th there was every indication of this storm passing away, but these indications suddenly ceased, and those of storm No. 2 appeared, which followed closely. It might be said that No. 2 dovetailed into No. 1. During the greater part of these storms calms and light winds prevailed, as noted on the records of observations.

Our heavy rainfalls heretofore have always followed several months of pressure below the normal, and this is the first time that the contrary has been the case since this office was established. It was with this fact in view that, in my summary for November, 1903, I said: "The barometric average for the past five months has been slightly above the normal, a condition likely to be followed by a winter of moderate rainfall," the authority for the statement being the records of this office. Mr. Lyons tells me that in all his experience he has never known a like condition.

The accompanying barogram, from noon of February 8 to noon February 15, shows that during the first three days there